CONTRIBUTIONS TO A KNOWLEDGE OF THE CRAMBINÆ OF NORTH AMERICA. I.*

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Since undertaking a study of the Pyralid subfamily Crambinæ it has been found that the little that has been published concerning it is so widely scattered and so fragmentary that it is very difficult of access. In the present series of papers the writer proposes to bring together all the available information concerning each species, both that previously published and that which has resulted from his own work. Both systematic and biological data will be included when available but the papers cannot be exhaustive for our knowledge of many points is too scanty. They are designed to afford a convenient starting point for further work by making it unnecessary for others to go repeatedly over this same ground and to put within reach of economic workers the available facts which may be useful in economic studies of these insects. The bibliographies are intended to be complete and the writer will welcome corrections and additions thereto.

Crambus hemiochrellus Zeller.

Systematic History. Aside from descriptions of the adult little has been published concerning this species. It was originally described by Zeller (1877). Grote (1880) listed it among the American species of the genus *Crambus*. It was reduced to a variety of *mutabilis* by Smith (1891) in which error he was followed by Felt (1894). Hampson (1895) placed it as a synonym of *luteolellus* but Fernald (1896) redescribed and re-established the species as valid and it so appears in Dyar's (1902) catalog.

Distribution. Zeller's specimens, all of which were sent him from this country, were collected in Dallas and Bosque Counties, Texas. These are the only localities appearing in the published records. To them the writer can add Chattanooga, Tenn., Wellington, Kan., and Elk Point, S. D., moths having been taken at the first two places by himself and at the last

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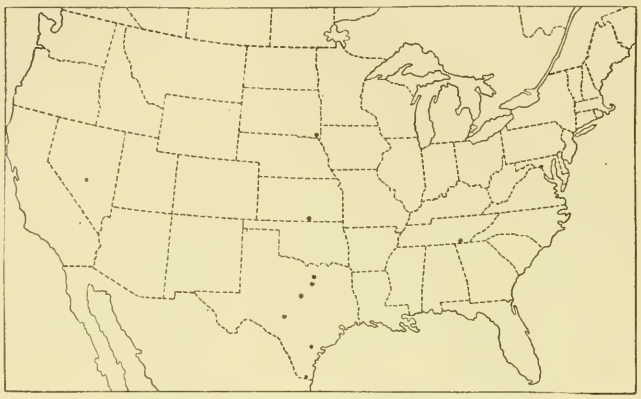
by Mr. C. N. Ainslie. The nineteen specimens in the collection of the U. S. National Museum bear locality labels from Devil's River, Dallas, Victoria, Sabinal, Kerrville, Plano and Brownsville, Texas, one simply "Ariz." and one taken at light at Washington, D. C. From these scattered data no definite limits for the distribution of the species can be fixed but in spite of its comparative rarity it appears to be widely diffused. The map below shows the location of the above mentioned localities.



Map of the United States showing points at which *Crambus hemiochrellus* has been collected.

Food Plants. Nothing is known of the normal food plants. Larvæ were easily reared to maturity on bluegrass (*Poa pratensis*) and doubtless would have accepted any one of a large number of grasses in common with other species of the genus.

Seasonal History. Zeller states that the moths fly in Texas during the last half of May. The first moths seen by the writer were those taken at Chattanooga on June 11. Others were taken at Wellington, June 27, and at Elk Point, July 19. All of these were captured alive and sent at once to the Bureau Field Laboratory at Nashville, Tenn., where eggs were obtained and larvæ reared from each lot. The larvæ from the Chattanooga moths pupated as soon as mature and adults emerged on August 5, 7, 11, 14 and 15. Part of the larvæ from the Kansas moths pupated as they reached maturity and moths emerged August 23, 26, 30, and September 2 and 13. The rest of the larvæ in this series did not pupate but continued slowly

to feed until they were supplied with damp sand in which they at once constructed retreats. They lay dormant in these retreats for weeks and the last of them died the following January without further change. The larvæ resulting from the South Dakota moth showed this same habit though in a more pronounced degree for none of them pupated in the fall and all died during the winter. If these overwintering larvæ could have been kept under exactly suitable conditions they would without much doubt have pupated in the spring and formed the first generation of moths. Attempts were made to breed the moths which emerged in the cages but no fertile eggs were obtained.

A consideration of the foregoing data together with the dates of collection of the moths in the National Museum indicate that in the latitude of Tennessee and southward there are two complete generations each year, the moths of the first appearing during the first half of June and of the second about two months later, in August. The collection of other moths at Wellington, August 8 and 15, by Mr. C. L. Scott, lends further support to this hypothesis. Somewhat farther north there is a complete first and a partial second generation, some of the offspring of the first remaining as larvæ until the following spring. As far north as South Dakota it is likely that few if any of the larvæ resulting from moths of the first generation pupate the same year. It appears that even in Texas there are but two generations in a year as no moths are recorded from there later than July 22. It is possible, however, that there is a complete or partial third generation in which case further collections should show moths appearing there in September.

Habits of Moths. Of the habits of the moths little is known. Those taken at Chattanooga were flying in a dry grassy field in company with *C. caliginosellus* which they so closely resembled in manner of flight and general coloration that the presence of two species was not suspected until they were examined later. At Wellington the moths, perfect unrubbed specimens, were attracted to a light trap. Eight of the nineteen specimens in the National Museum were taken at light. It is an indication of the scarcity of the species that with its positive phototropic tendencies so strongly marked it is not more commonly met with in collections.

Egg Laying Habits. The three captured females of which records were kept laid respectively 147, 184 and 303 eggs in confinement. A number of the reared moths of both sexes were confined together but eggs, 92 in number, were obtained from but one female and they were infertile.

Rearing Methods. Larvæ were found to be comparatively easy to rear. Four series were reared from the egg and adults were obtained in three of them. The larvæ were confined in half-ounce tin salve boxes floored with damp blotter to keep the food fresh and absorb excess moisture. They were examined daily, fed, and the boxes cleaned as often as necessary. They were fed only on bluegrass cut in short lengths. Larvæ in each instar were described and preserved. In one series a record was kept of the amount of food consumed. The data given in the rest of this paper are derived from these rearings and while perhaps varying somewhat from actual field conditions give at least a basis for comparison with other species reared by similar methods.

Stage and Instar Records. The duration of the egg stage is variable, being directly dependent on temperature. The length of the first instar is also variable for some larvæ began at once to feed while others remained inactive for two or three days. Up to the seventh instar the rate of growth is very consistent. Here a complication arises for the instar immediately preceding the change to the pupa is always the longest whether it be VII, VIII or IX. Three larvæ which pupated from VII passed 13 days each in that instar while 15 larvæ which molted to VIII averaged but 4 days in VII. This explains the sudden increase in the maximum length of the seventh and succeeding instars in Table I in which are condensed the data secured as to length of instars and stages.

TABLE I.

LENGTH IN DAYS OF INSTARS AND STAGES.

Stage	Maximum	Minimum	Average	Number Averaged
Egg	9	8	9	...
Larva	47	39	43.6	9
Instar I	8	2	5.09	121
II	5	2	3.33	107
III	5	2	3.25	87
IV	7	2	3.64	79
V	9	2	4.62	67
VI	7	2	4.23	58
VII	17	2	5.18	50
VIII	14	3	7.66	41
IX	22	4	10.60	16
X	8	8	8	1
Pupa	14	9	10.40	10

The normal number of instars for the larvæ of this species is probably seven for the males and eight for the females, though some individuals in each of the reared series exceeded this number. One even reached the twelfth instar. Table II gives the larval measurements for the various instars.

TABLE II.

LARVAL MEASUREMENTS IN MILLIMETERS.

Instar	Head Width		Average	Number Averaged	Body Length
	Maximum	Minimum			
I	.....	.....	.194	..	1.2
II	.....	.....	.264	..	2.0– 2.8
III	.424	.318	.362	16	3.0– 4.0
IV	.580	.440	.524	14	6.0
V	.880	.635	.750	16	8.0–10.0
VI	1.165	.724	.920	19	10.0–12.0
VII	1.483	1.130	1.318	11	15.0
VIII	1.726	1.119	1.586	21	20.0
IX	1.632	1.213	1.446	21	23.0
X	1.586	1.353	1.469	4	.....

Table III shows the sex and the instar at pupation of nine of the moths reared.

TABLE III.

Number moths reared	Last larval instar	Moths Emerging	
		Male	Female
2	VII	1	1
2	VIII	2	0
4	IX	2	2
1	X	0	1

During the first three instars the larvæ fed mostly by skeletonizing the leaf, leaving only the membrane on one side. Part of those in III and all from that time on consumed the entire leaf. The amount of food consumed progressed in a fairly definite ratio, the amount eaten in any instar being about 100% greater than that eaten in the preceding instar. In this respect a larva about to pupate behaved differently than one still growing for during the last instar its desire and capacity for food seemed almost insatiable until within two or three days of pupation when it ceased entirely to feed, contracted, became sluggish and prepared for the change. It is noteworthy that larvæ of this species did not eat the molted larval skins and head casts as do those of many species of *Crambus*. The larvæ in the series of which the food record was kept were given measured pieces of bluegrass leaves and at the end of each instar the uneaten portion was removed and measured. A skeletonized leaf was considered to be two-thirds consumed. Table IV shows the amounts of food consumed by the larvæ in each instar in linear millimeters of bluegrass leaves which average about 3 mm. in width.

TABLE IV.

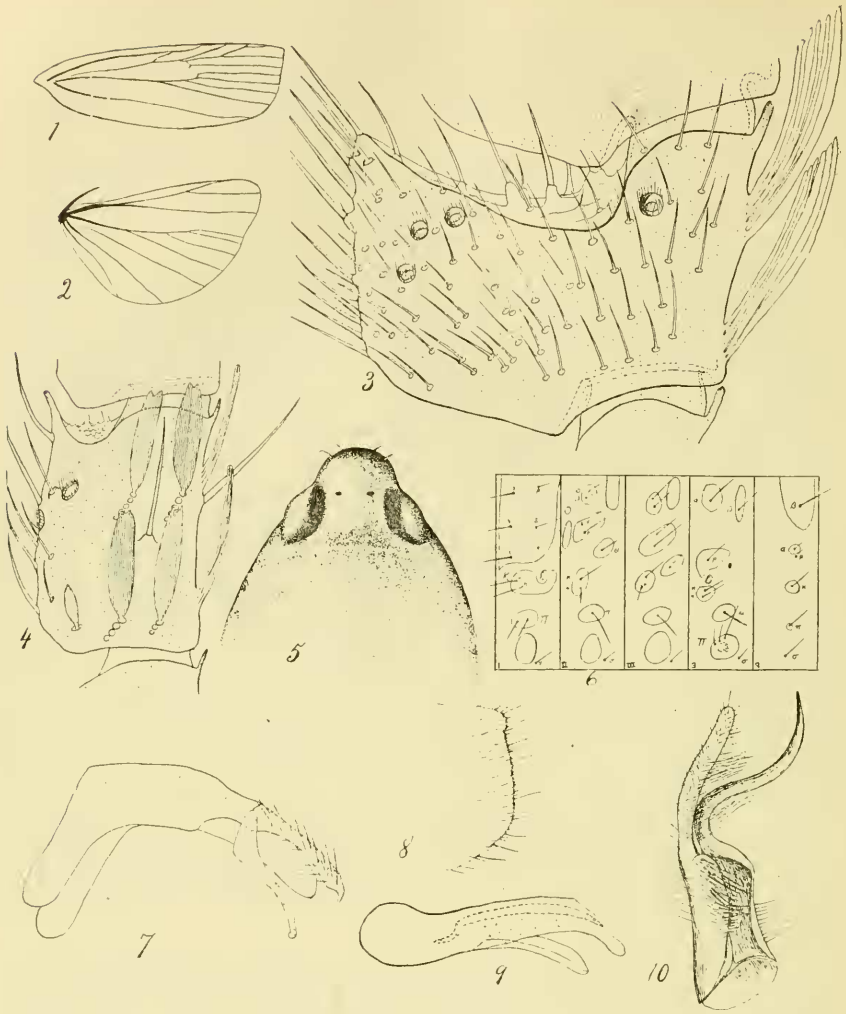
BLUEGRASS LEAVES IN LINEAR MILLIMETERS CONSUMED.

Instar	Maximum	Minimum	Average	Number larvae averaged
I	6	2	3	41
II	16	1	7	36
III	20	3	13.7	26
IV	33	5	19.4	25
V	82	19	45.5	23
VI	176	18	101	21
VII	1095	38	336	11
VIII	990	190	474	13
IX	1370	180	832	6
X	420	420	420	1

Systematic Position. In its relationships this species lies between *C. trisectus* and *C. mutabilis*, more closely allied to the latter. The moth resembles that of *mutabilis* in the dark shading on the costa proximad, the dentate subterminal line and the whitish veins in the middle of the forewing. It is, however, more richly colored than that species and especially do the yellow stripes in the posterior half of the primaries contrast with the much less lively coloration of *mutabilis*. Structurally its close approach to *mutabilis* is shown in the narrow forewing, the broadly pectinate male antennæ, the naked spine-like harpe (Fig. 10) and the hooked uncus (Fig. 6). It differs in that the male antennal processes (Fig. 3) are less abundantly supplied with sensoria, the scaphium is longer, the valve is both longer and somewhat wider and the harpe while spine-like is large, doubly curved and long, exceeding the valve. This latter character in itself is sufficient to define the species for in *mutabilis* the harpe is a slender spine not more than half the length of the valve and in *trisectus*, the nearest form on the other side, the harpe is falcate and setigerous and in length about equals the valve. The relationship to *mutabilis* is shown also by the larvæ for the markings of the two are very similar differing only in shade, brick-red for *hemiochrellus* and dull brown for *mutabilis*. During their incubation period the eggs of the two species assume very nearly the same shade, a pale salmon-yellow.

Descriptions. Adult: The description of the adult moth as given by Fernald (1896) is very accurate and complete and is here quoted with the addition of a description of the genitalia by the writer.

Expanse of wings, 22 mm. Head and thorax pale ochre-yellow; palpi thickly sprinkled with grey atoms. Fore wings bright ochre-yellow between the white median vein and hind margin with dusty stripes, and usually with a clear yellow stripe along the fold; costal portion yellowish-gray, darker toward the base; median line fine, rust-brown, forming an acute angle at the end of the cell, and extending in a nearly straight line to the middle of the hind margin; subterminal line fine, dark brown, dentate on the veins and parallel with the outer margin except at the costal end, where it curves sharply inward and terminates at the outer fourth of the costa; terminal space dusty-gray; terminal line rather indistinct, upon which in some specimens, may be seen seven very fine dark gray dots; fringes light gray. Hind wings light gray; fringes lighter.



EXPLANATION OF FIGURES.

Fig. 1. Venation of fore wing.
Fig. 2. Venation of hind wing.
Fig. 3. Antenna, male, 25th segment.
Fig. 4. Antenna, female, 25th segment.
Fig. 5. Tip of pupa, dorsal view.
Fig. 6. Setal map showing arrangement of pinacula and setae on three thoracic segments and the 3rd and 9th abdominal.
Fig. 7. Male genitalia, scaphium, uncus and lower limb.
Fig. 8. Female genitalia, edge of anal plate.
Fig. 9. Male genitalia, penis.
Fig. 10. Male genitalia, clasp showing harpe and valve.

Genitalia. Female—Anal valve (Fig 8) broad, nearly square in outline, not constricted at the base, dorsal angle rounded and slightly produced. Male—All parts uniformly and moderately chitinized; body of scaphium (Fig. 6) narrow, slightly longer than the limbs, which are narrow and rounded distad; uncus slender, elongate, slightly enlarged distad and ending in a small but distinct sharp hook, hirsute above, lower limb very slender, exceeding the uncus, its branches very short, naked; clasps (Fig. 10) strongly concave at the base, valve slender, elongate, uniformly clothed on the inner surface with fine hair and at its base a heavily spined, rounded lobe; harpe a long, strong, S-shaped, naked spine, exceeding the valve; penis (Fig. 9) moderately chitinized, bulbous at base and tapering to an obliquely truncate, curved tip, hollow, open at the end, with a slender, chitinous internal spine more than half the length of the organ extending nearly to the tip, the whole organ subtended by a weakly chitinized plate attached about the middle.

Our specimens agree exactly with the descriptions of Zeller and Fernald except that in some individuals the terminal line is somewhat more distinct than they indicate and the forewings of our specimens do not have the acute apex with the slight curve beneath that Zeller mentions.

The larva, especially in the later instars is easily distinguished from other Crambin larvæ we have seen by its color, a bright brick-red arranged in longitudinal stripes separated by irregular broken white lines. The head, black in the newly hatched larva, becomes in the larger instars a clear pale yellow, in some individuals faintly clouded with darker yellow. Technical descriptions of the egg, larval and pupal stages follow. Terms as defined and used by Fracker for the larva and Miss Mosher for the pupa are used. Larval measurements are condensed in Table II and are therefore omitted from the descriptions.

Egg. Elongate oval, bluntly rounded at both ends one of which is slightly smaller than the other; chorion with 17 acute longitudinal ribs, 5 or 6 of them running to the pole at each end, the others appearing as the interspaces widen; interspaces faintly transversely striate throughout their length. Measurements (10 eggs):

Length, maximum .529 mm., minimum .460 mm., average .496 mm.
Width, maximum .318 mm., minimum .300 mm., average .307 mm.

The eggs are pure white when laid, when a few hours assume a yellowish tinge and at the end of three or four days become pale salmon-yellow, remaining thus until about twenty-four

hours before hatching, when the black head and dark cervical plate show as a spot and transverse band close to one end of the egg. The hole through which the larva emerges is made at one side of the larger end of the egg, its edge usually just reaching the pole. The empty shell is transparent and iridescent.

Larva. Instar I.—Head black, cervical plate deep fuscous to black; body when first hatched clear pale yellow with minute pinacula, which later become dingy and more conspicuous.

Instar II.—Head uniformly fuscous, mouth-parts paler, ocellar area and latero-caudal margin of head black; Cervical plate fuscous, a little paler than head. Pinacula on meso- and meta-thorax small, dusky, those on abdomen larger and more conspicuous because of a shaded pigmented area just cephalad of each. Abdomen tinged with brick-red and already showing faintly the striped pattern of the larger larvæ.

Instar III.—Head uniformly clear brownish-yellow, cervical plate concolorous with head or a little paler. Pinacula dusky and conspicuous, larger and more deeply pigmented caudad. Spiracles small, dark, not prominent in all specimens.

Instar IV.—Head clear pale yellow without markings except the black ocellar area and latero-caudal margin; mouthparts outlined and the facial sutures marked by very fine dark lines. Cervical plate pale fuscous, darker than head. Pinacula on thorax and abdomen large, mostly surrounded by shaded pigmented areas which make them appear larger. Body plainly longitudinally striped with red, the stripes running one between the dorsal line and alpha and the other between beta and rho on each side, four main stripes separated by narrow whitish more or less broken and irregular lines.

Instar V.—Head uniform clear pale yellow, mouthparts outlined with fine dark lines, ocellar area crescent-shaped, black. On the margin of head caudad of ocellar area is a small black spot from which a heavy dark line runs dorsad margining the head to the vertical triangle. Cervical plate large, pale yellow, darkening laterad and with a small dark spot in the center of each lateral extremity. Spiracles small black, nearly round and with a black cicatrix of the same size but more elongate, caudad and a little dorsad on each of the pedal segments.

Instar VI.—Head clear pale yellow, some faintly clouded with darker yellow, ocellar area black, crescent-shaped, caudal margin of head black beginning at a small black spot caudad of ocellar area. Cervical plate broad, pale, slightly darker than head, with paler median stripe and a faintly dusky spot near the lateral margin.

Instar VII.—Head clear pale yellow, occasionally slightly clouded with darker yellow, black latero-caudal marginal line distinct but becoming faint toward vertical triangle. Facial sutures indistinct, mandibles dark, ocellar area reduced in size, the two terminal ocelli

isolated. Cervical plate large, concolorous with head or somewhat paler, with a pair of medio-lateral spots and dark prominent setæ; cicatrices on pedal segments prominent, black, of the same size as the spiracles.

Instar VIII.—Head clear pale yellow, faintly clouded with dark, ocellar area black, caudal margin of head black beginning at a black spot on margin of genæ; setæ on face pale brown, arising from minute clear, brown-edged circles. Cervical plate large, pale, concolorous with head or paler, with small brownish spot near lateral extremity and a group of dots on each side of median line near caudal margin, median line pale. Kappa almost directly dorsad of eta on the abdominal segments. In live specimens the pinacula have their outlines obscured by the reddish stripes which cross them. These stripes appear first in II and III and become more pronounced until in the older larvæ they give the color to the whole body. They run as follows: a narrow medio-dorsal line, a wider one on each side of this and separated from it by a narrow broken whitish stripe runs through the outer half of pinacula alpha and includes beta, between this and rho runs another white line similar to that dorsad of alpha below which the spots and body are various shades of suffused red, pink and salmon. The larva as a whole appears of a bright brick-red color. In alcohol the red striping disappears.

Pupa (Fig. 5)—Length 9 mm., width 2.7 mm. Of the usual pyralid shape, yellowish brown, the sutures marked by narrow maroon lines. Epicranial suture obsolete; fronto-clypeal suture present only at margin, running a short distance meso-ventrad from the ventral corner of the antennæ; front with a large, dark, flattened and somewhat depressed tubercle mesad on ventral margin and a small dark point mesad near caudal margin of clypeus; maxillæ almost equaling wings; tarsi of prothoracic legs ending about two-thirds of the distance from vertex to caudal margin of wings; antennæ extending about half way from the tips of the mesothoracic tarsi to the caudal margin of the wings; prothorax large, strongly convex cephalad, caudal margin straight and only slightly elevated and wrinkled laterad for the prothoracic spiracles; mesothoracic wings extending to caudal margin of fourth abdominal segment; cremaster short blunt, rounded or feebly angled distad, above sloping with two minute attenuate spines at the angles and with a short deep curved furrow on each side running from the base cephalad, laterad and ventrad finally becoming obsolete on the lateral line, beneath excavated and flattened, the distal angles each bearing a spine like those above, but smaller and closer together.

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